
Figures

Year Class	Management Objectives
Extremely Wet	<ul style="list-style-type: none"> • Mobilization of matrix particles (D_{84}) on alternate bar surfaces (Attribute 3) • Channelbed scour greater than 2 D_{84}'s depth and redeposition of gravels on face of alternate bars (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Periodic channel migration (Attribute 6) • Floodplain creation, inundation, and scour (Attribute 7) • Channel avulsion (Attribute 8) • Woody riparian mortality on lower alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain variable water table for off-channel wetlands and side channels (Attribute 10)
Wet	<ul style="list-style-type: none"> • Mobilization of matrix particles (D_{84}) on alternate bar surfaces (Attribute 3) • Channelbed scour greater than 1 D_{84}'s depth and redeposition of gravels (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Periodic channel migration (Attribute 6) • Floodplain creation, inundation and occasional scour (Attribute 7) • Woody riparian mortality on lower alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain fluctuating water table for off-channel wetlands and side channels (Attribute 10)
Normal	<ul style="list-style-type: none"> • Mobilization of matrix particles (D_{84}) on general channelbed surface and along flanks of alternate bar surfaces (Attribute 3) • Channelbed scour and redeposition of gravels (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Frequent floodplain inundation (Attribute 7) • Woody riparian vegetation mortality along low water edge of alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain fluctuating water table for off-channel wetlands and side channels (Attribute 10)
Dry	<ul style="list-style-type: none"> • Channelbed surface mobilization of in-channel alluvial features (e.g., spawning gravel deposits) (Attribute 3) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Discourage germination of riparian plants on lower bar surfaces for a portion of the seed release period (Attribute 9) • Maintain variable water table for off-channel wetlands and side channels (Attribute 10)
Critically Dry	<ul style="list-style-type: none"> • Discourage germination of riparian plants on lower bar surfaces for the early portion of the seed release period (Attribute 9) • Minimally recharge groundwater (Attribute 10)

Figure 1: Primary fluvial geomorphic management objectives for the Trinity River by water-year class. Source: USFWS and Hoopa Valley Tribe (1999).

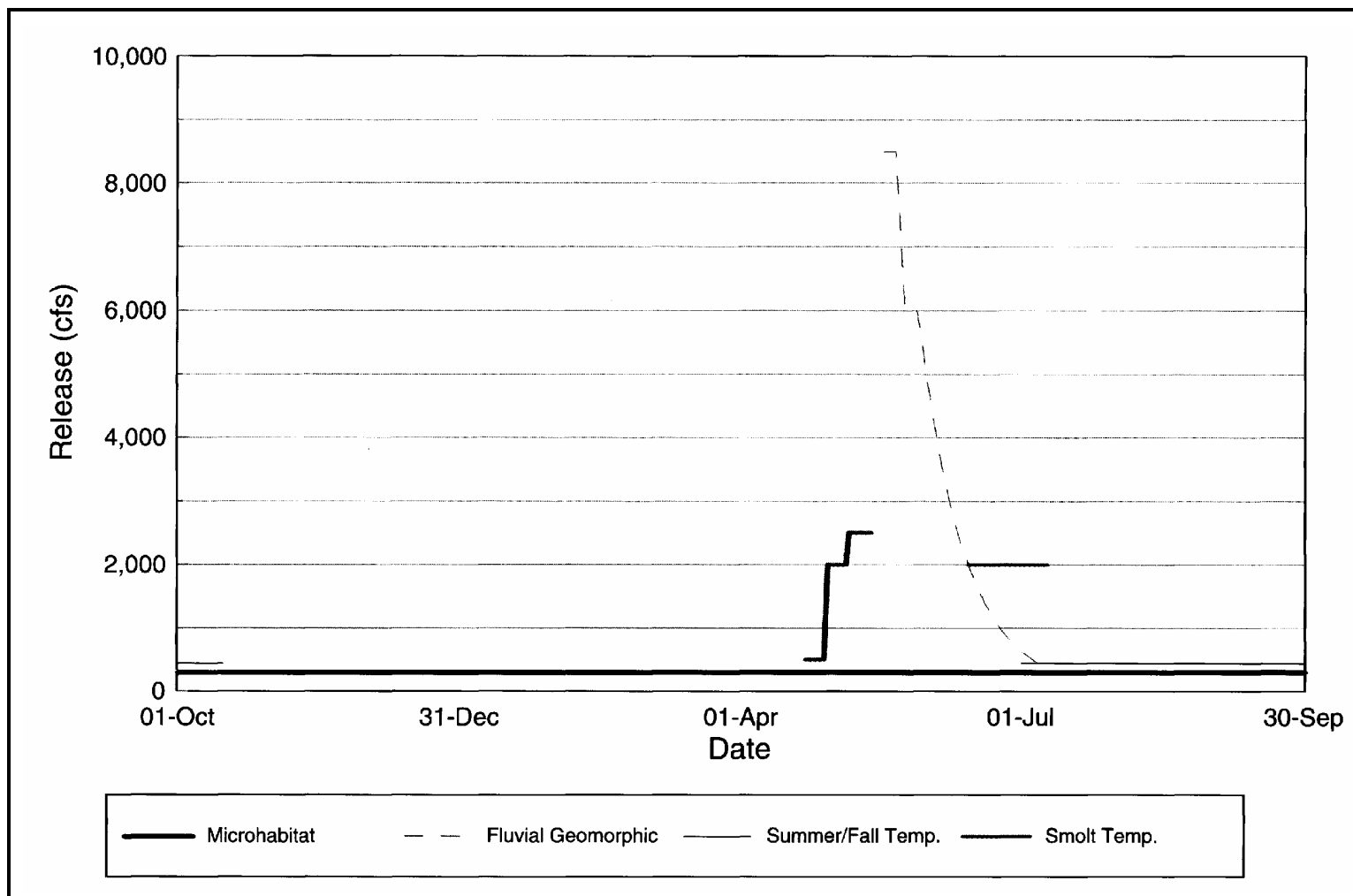


Figure 2: Flow releases necessary to meet microhabitat, fluvial geomorphic, summer/fall temperature, and smolt temperature management objectives during a West water year. Source: USFWS and Hoopa Valley Tribe (1999).

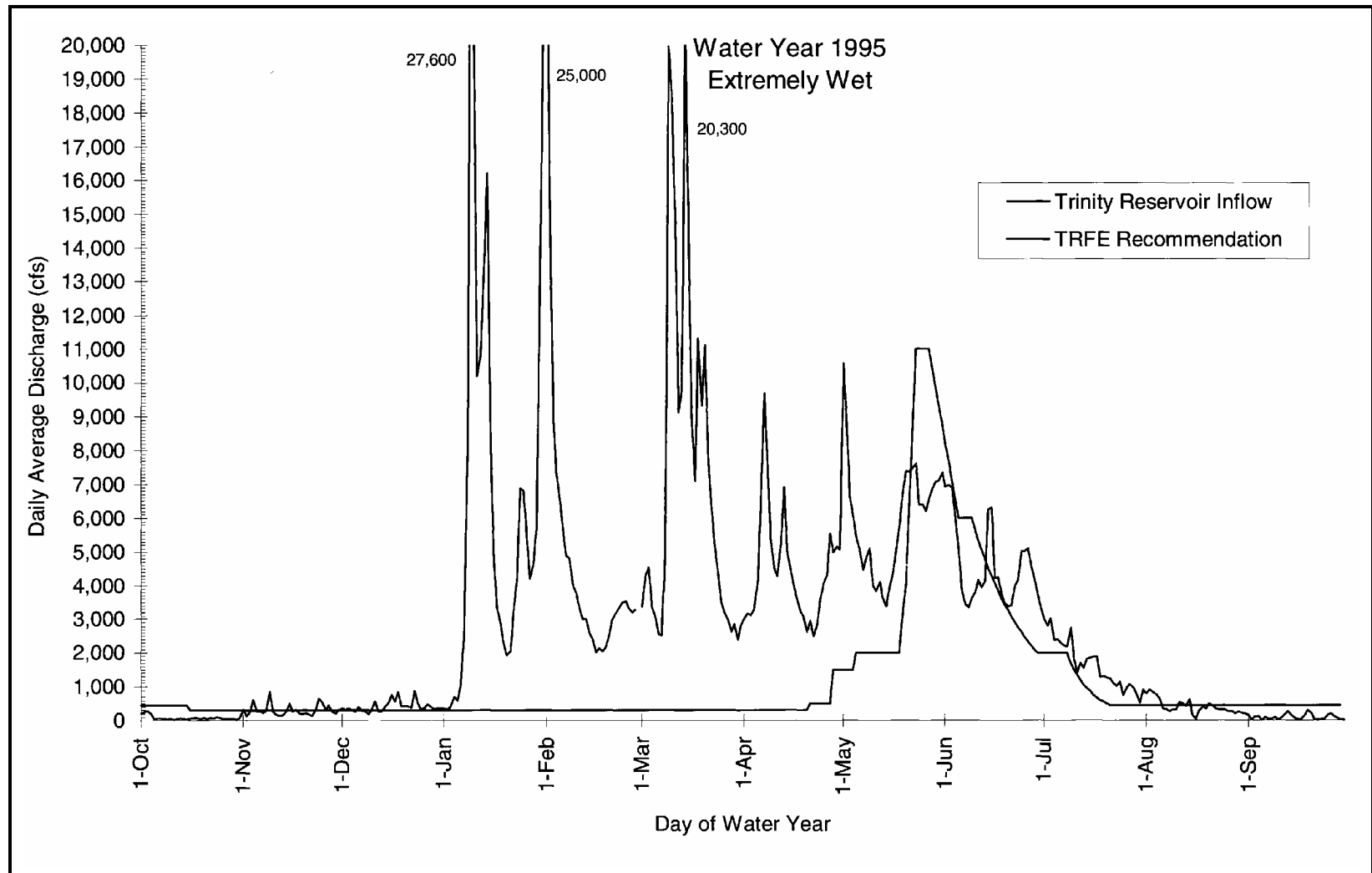


Figure 3: Recommended releases during an Extremely Wet water-year compared to unimpaired inflow to Trinity Lake for WY 1995. Source: USFWS and Hoopa Valley Tribe (1999).

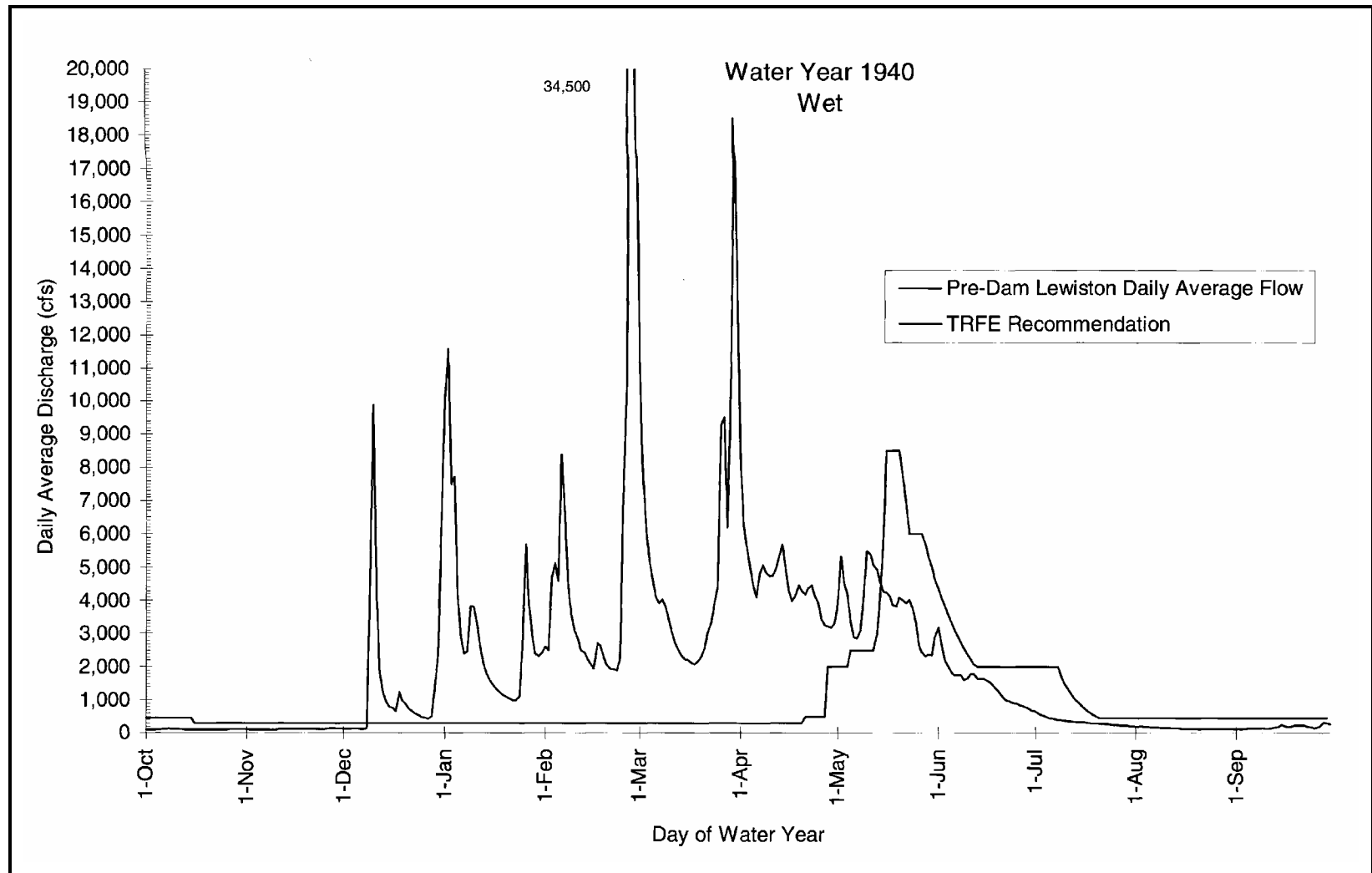


Figure 4: Recommended releases during a Wet water-year compared to unimpaired inflow to Trinity Lake for WY 1940. Source: USFWS and Hoopa Valley Tribe (1999).

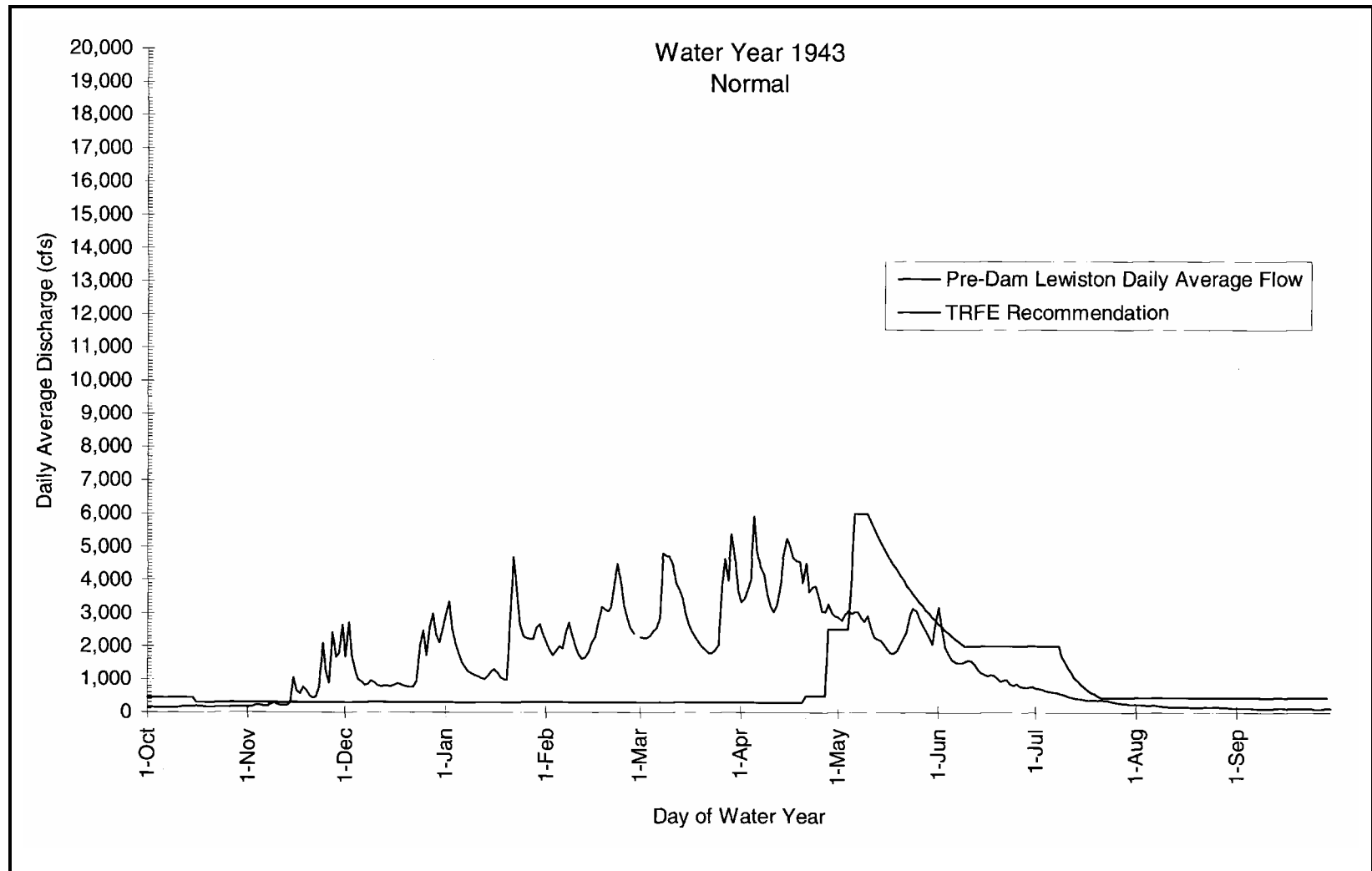


Figure 5: Recommended releases during a Normal water-year compared to unimpaired inflow to Trinity Lake for WY 1943. Source: USFWS and Hoopa Valley Tribe (1999).

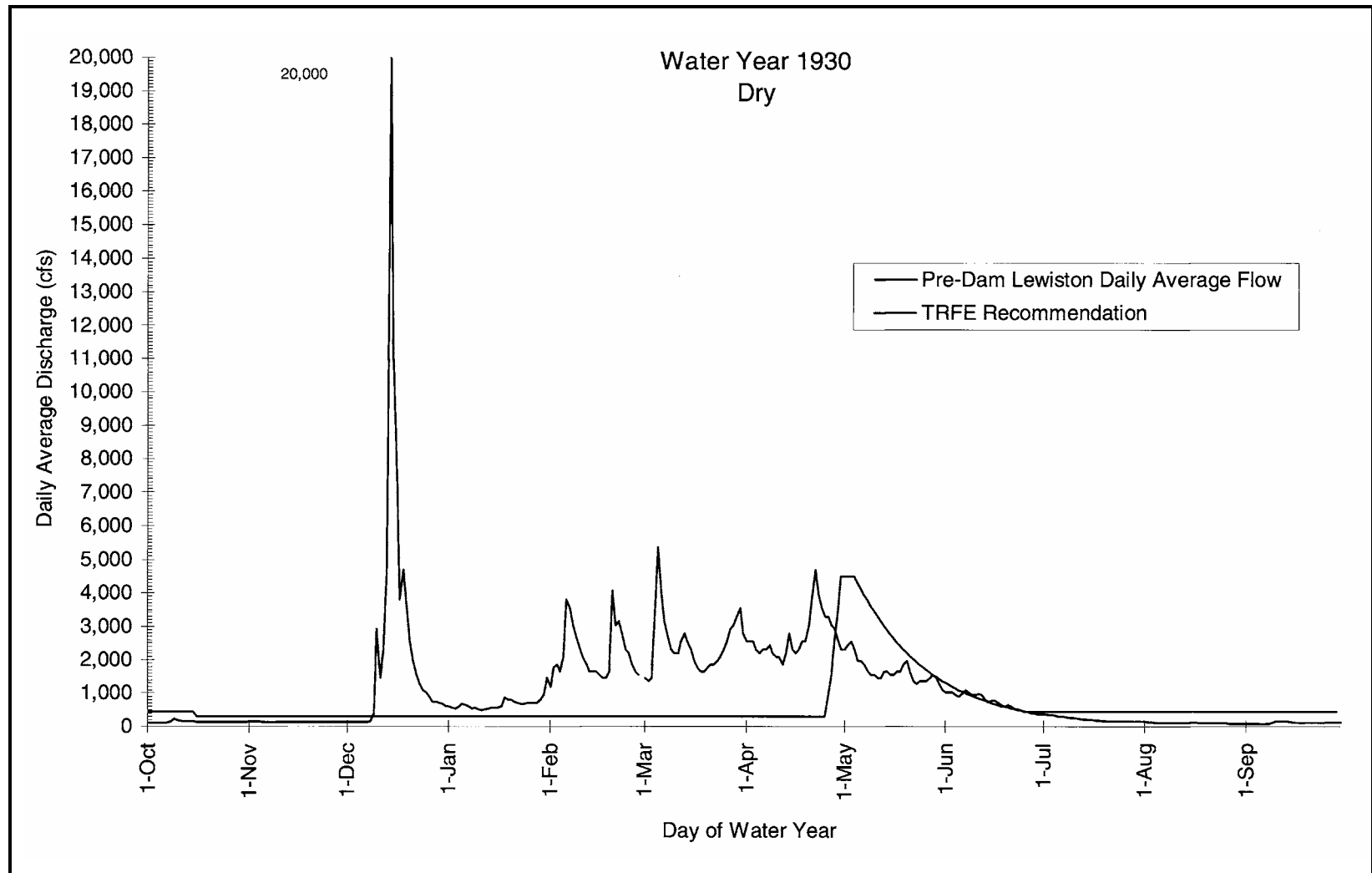


Figure 6: Recommended releases during a Dry water-year compared to unimpaired inflow to Trinity Lake for WY 1930. Source: USFWS and Hoopa Valley Tribe (1999).

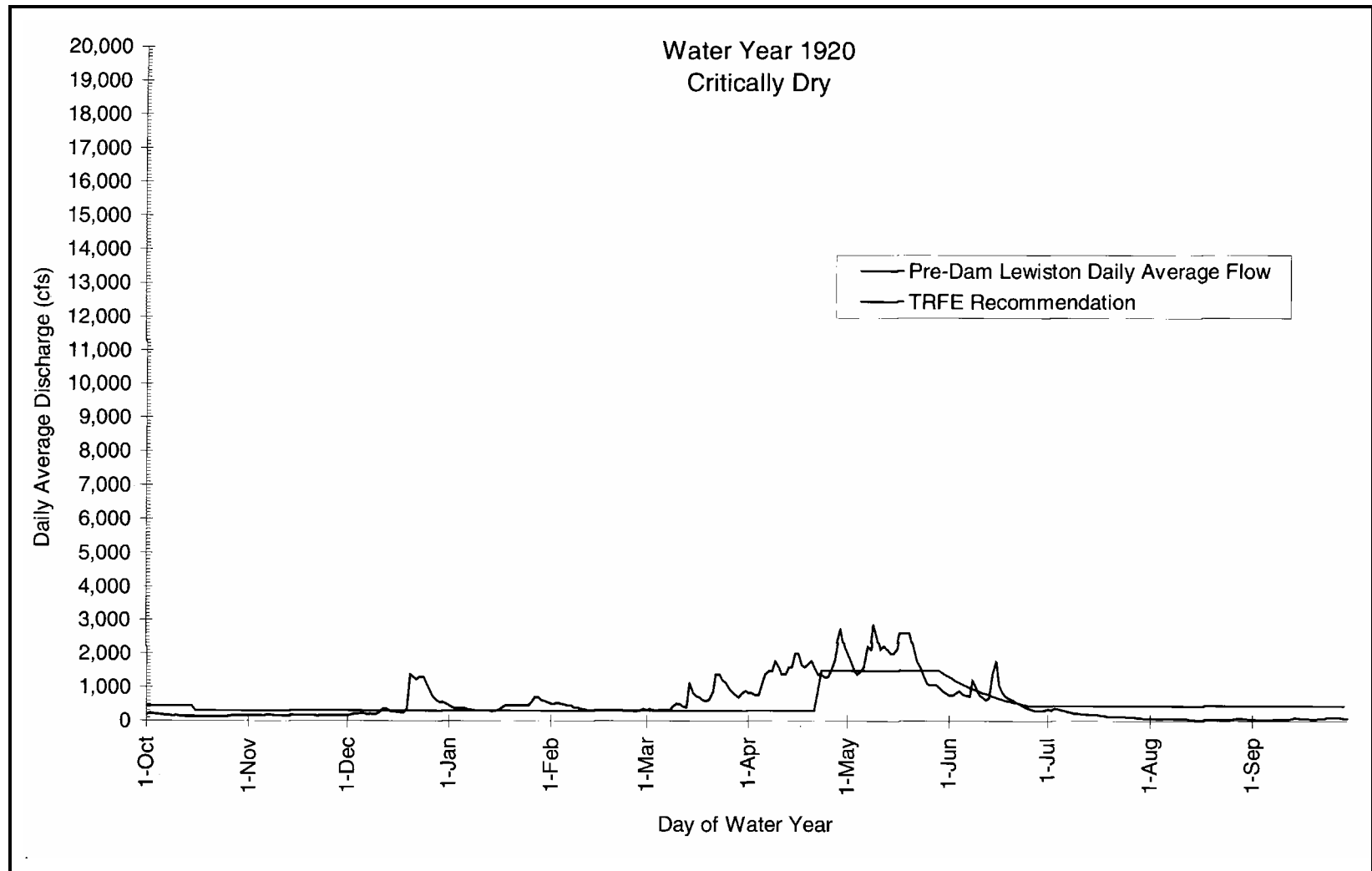


Figure 7: Recommended releases during a Critically Dry water-year compared to unimpaired inflow to Trinity Lake for WY 1920. Source: USFWS and Hoopa Valley Tribe (1999).

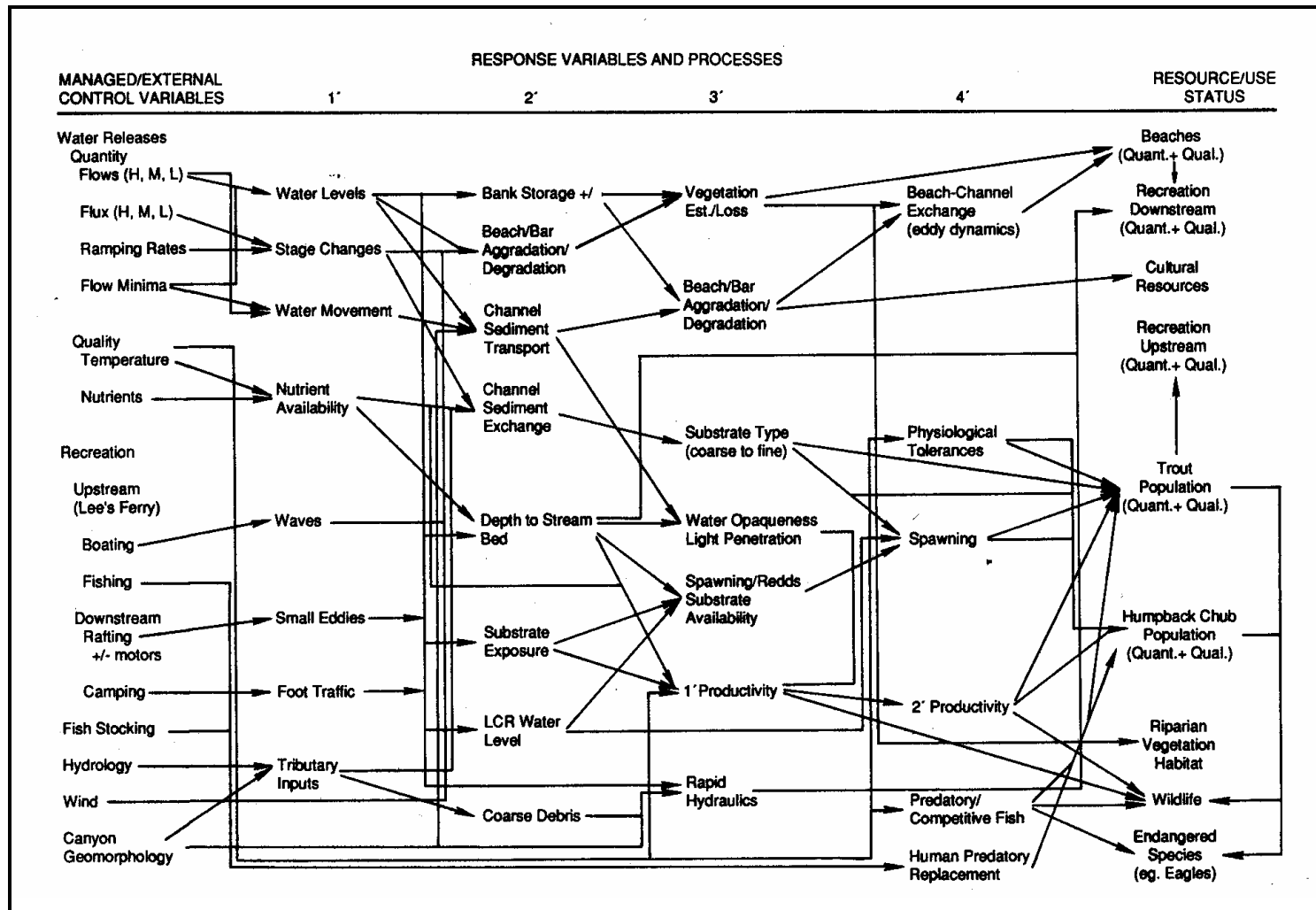


Figure 8: Interrelationships and stepwise connections of response variables and processes between controlling variables and Canyon resource and use status – GCES. Source: NRC (1991).

I. Effects of Dam Operations

A. Effects of the Magnitude of Daily Discharge Fluctuations, Minimum Discharges, and Rate of Change (Ramping) of Fluctuating Discharges.

Q-1.1. How significant are discharge fluctuations, minimum discharge and ramping in the degradation or aggradation of beaches?

Q-2.1. Do discharge fluctuations, differences in minimum discharges, or different rates of change in daily discharges (ramping rates) interact with other uses and components of the Canyon to affect rates of sediment degradation?

Q-2.1a. What is the relationship between the effects of recreational use of beaches and the magnitude in daily discharge fluctuations, daily discharge minima, or daily ramping rates?

Q-2.1b. What is the relationship between the role of vegetation as a beach stabilizer and the magnitude of daily discharge fluctuations?

Q-3.1. How do daily discharge fluctuations, minimum discharges or ramping rates influence the amount of sediment stored in or transported in the Canyon system?

Q-4.1. How do discharge fluctuations, minimum discharges and rates of change of fluctuating discharges affect trout?

Q-4.1a. What is the relationship between the rate of stranding of trout and the magnitude of discharge fluctuations, minimum discharges, or the ramping rates?

Q-4.1b. What is the relationship between behavioral activity of rainbow trout and the magnitude of daily discharge fluctuations, daily minimum discharges and ramping rates?

Q-5.1. How do discharge fluctuations, minimum discharges and rates of change of fluctuating discharges affect foraging success of wintering bald eagles?

Q-5.1a. What is the relationship between trout availability, trout access, bald eagle presence, bald eagle abundance or bald eagle foraging success in the mainstream or Nankoweap Creek and the magnitude of daily discharges?

Q-6.1. How do discharge fluctuations and rates of change in fluctuating discharges affect the population dynamics (including short-term abundance of early life stages and potential predation relationships) of native (especially the humpback chub) and introduced fish species in the mainstem Colorado, including mainstem backwaters and the confluence of the Little Colorado?

Q-7.1. How are water quality (nutrient availability and other characteristics), stream productivity (of algae and macroinvertebrates), and import-export rates of organic matter to and from the Lee's Ferry reach influenced by the magnitude of discharge fluctuations, and the ramping rates?

Q-8.1. How are recreational variables (angler safety and rafting safety, satisfaction, experiential quality and economics) influenced by the magnitude of seasonal or daily discharge fluctuations, minimum discharges or the ramping rates?

Q-9.1. Are there sufficient camping beaches during maximum normal operations discharges from Glen Canyon Dam (i.e., 31,500 or 33,200 cfs) to satisfy the needs of the recreational rafting community based on the NPS acceptable carrying capacity of the Grand Canyon system?

Q-10.1. Do dam operations (e.g., magnitude of stage, magnitude of discharge fluctuations and/or ramping rates) affect the stability of cultural resource sites along the river in the Grand Canyon?

II. Effects of Recreation.

A. Effects of Fishing Activities.

Q-11.1. Does fishing activity, including boating, in the Lee's Ferry reach affect other Canyon resources?

Q-11.1a. Does fishing activity, including boating, affect beach stability, especially in the Lee's Ferry reach?

Q-11.1b. What is the relationship between the trout population of the Lee's Ferry reach and fishing activities, especially catch and release or keep relationships?

B. Effects of Rafting and Camping Activities.

Q-12.1. How does rafting and camping affect other Canyon resources, especially the sediment volume of beaches?

III. Effects of Economic Balances.

A. Power Economics.

Q-13.1. If creating a more stable environment in the Canyon below Glen Canyon Dam requires changes in power operations, what is the economic impact of these changes?

B. Recreational Economics.

Q-14.1. Are the economic benefits of downstream recreational activities as well as associated tourism services (e.g., lodging, airlines, restaurants, etc.) affected by operations of Glen Canyon Dam?

C. Non-use Economics.

Q-15.1. Are there any non-use benefits that are attributable to the maintenance of a stable environment in the Canyon below Glen Canyon Dam and if so would these values be affected by changes in dam operations?

IV. Potential Future Mitigation Alternatives in Addition to Modification of Discharge Criteria.

A. Effects of "No Change" Alternative.

Q-16.1. Are there any greater economic or environmental costs to the "no change" alternative if compared to the other alternatives?

B. Effects of Variable Intake Structures

Q-17.1. If a variable intake structure is used on Glen Canyon Dam, what will be the effects of intake at various levels on the downstream system?

C. Effects of A Reregulation Dam.

Q-18.1. If a regulation dam were constructed in the Canyon some where between Glen Canyon Dam and Lee's Ferry, what would be the effects of the discharges from this dam on the downstream system?

Q-18.2. What would be the impact of a reregulation dam on the Lee's Ferry reach if it is constructed in this reach?

D. Effects of Beach Protection Devices.

Q-19.1. Is it possible to mitigate the degradation of camping beaches in the Canyon due to dam operations using beach protection devices?

E. Effects of Sediment Augmentation.

No questions have been developed until methodology is identified.

Figure 9: Outline of short-term research questions for analyzing resource responses – GCES. Source: NRC (1991).

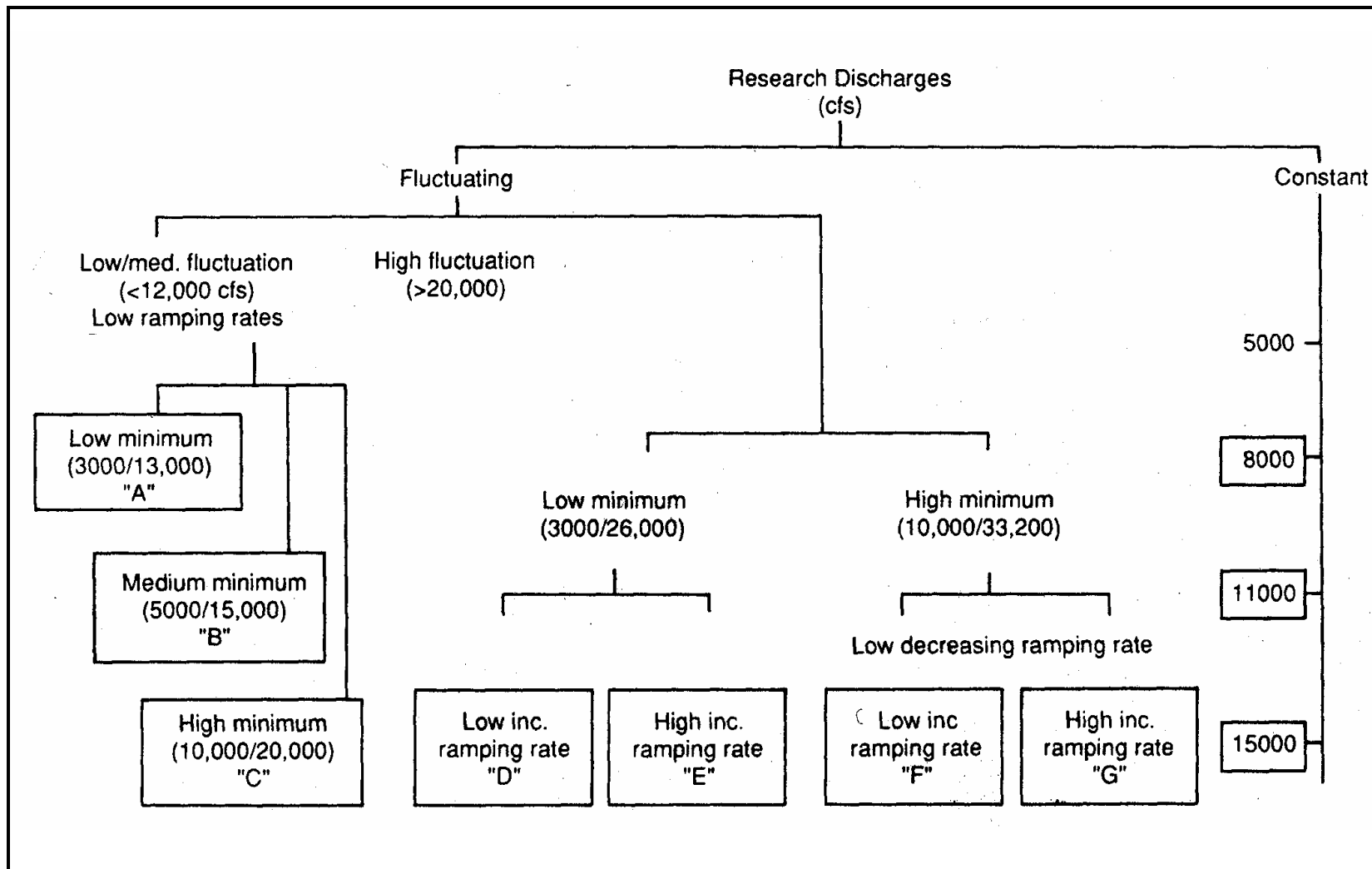


Figure 10: Dendrogram of research discharges – GCES. Source: NRC (1991).

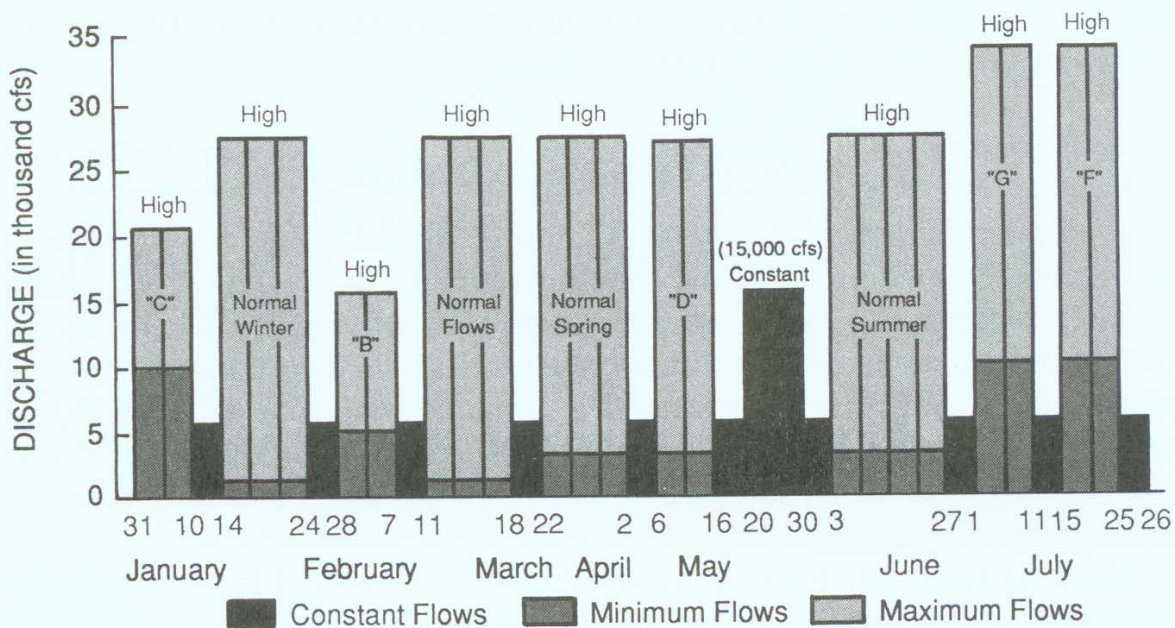
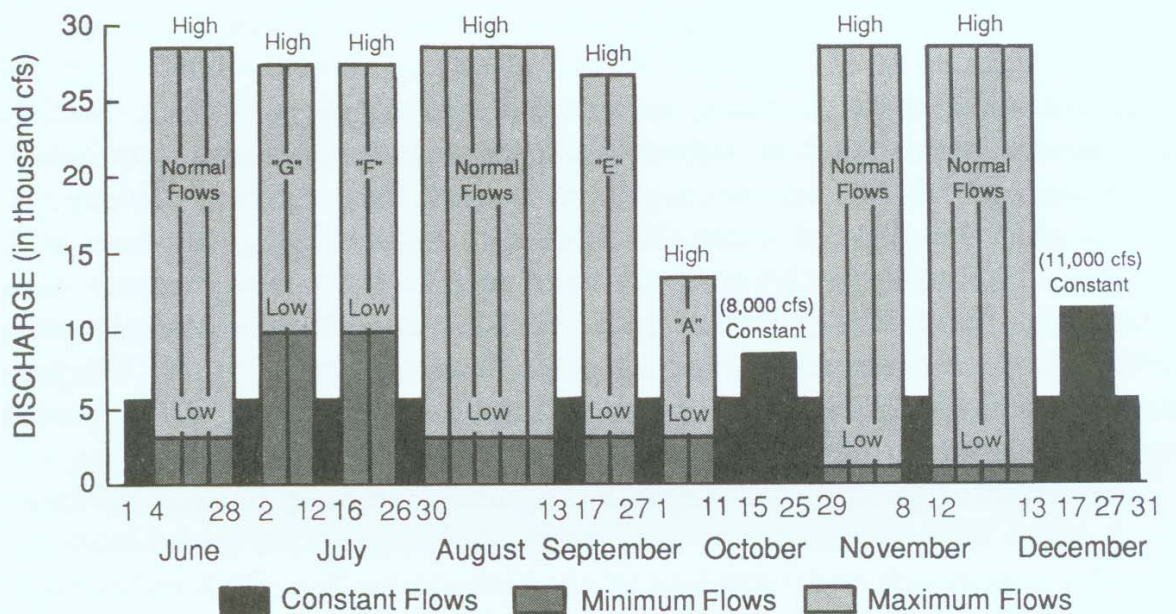


Figure 11: Research discharge flow schedules for 1990 and 1991-GCES. Source: NRC (1991).

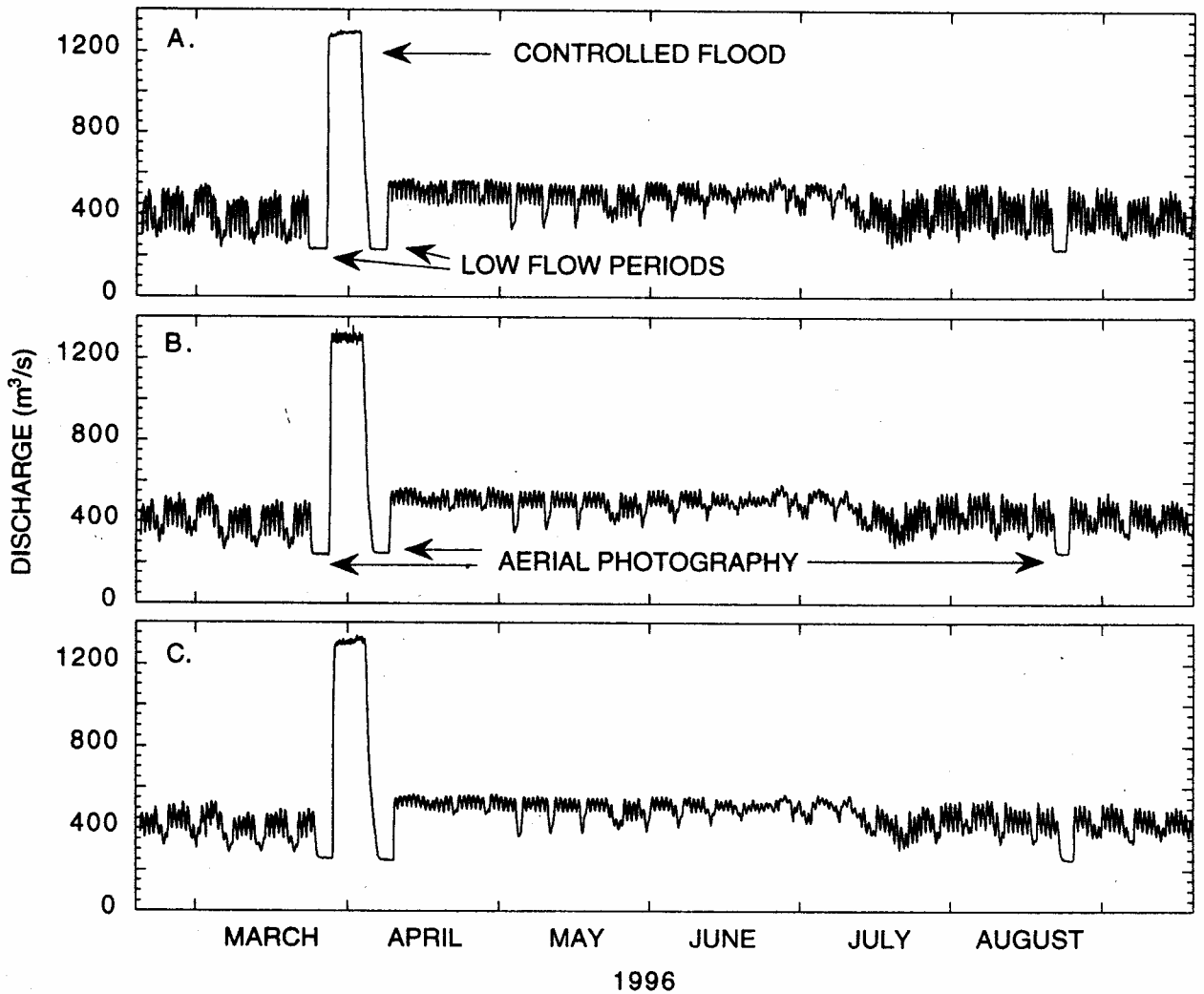


Figure 12: Hydrographs showing instantaneous discharges for the 1996 controlled flood at three locations in Grand Canyon – GCCF. Source: Webb *et al.* (1999).

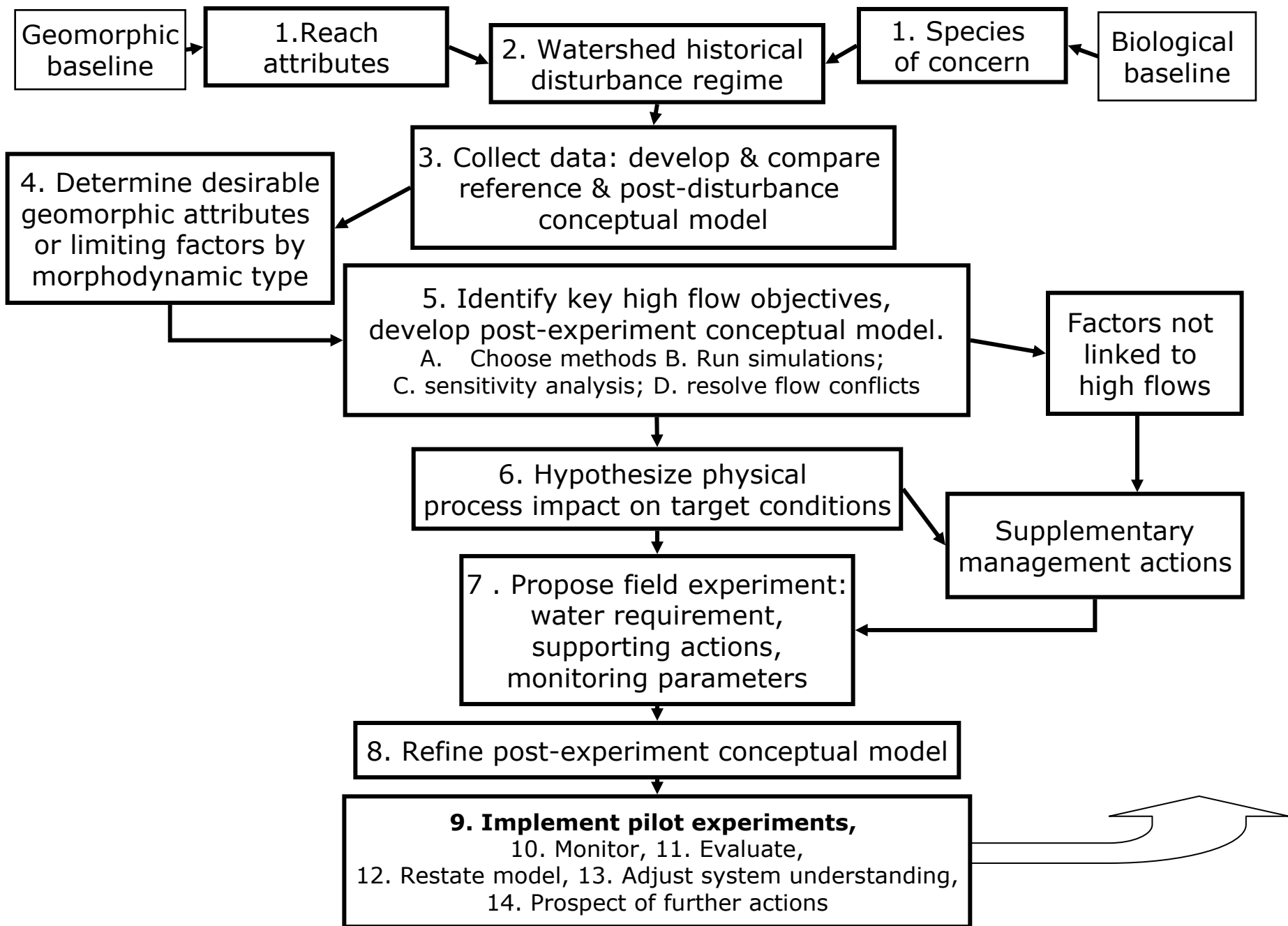


Figure 13: Adaptive management framework for high flow prescription. Developed from USFWS and Hoopa Valley Tribe (1999).

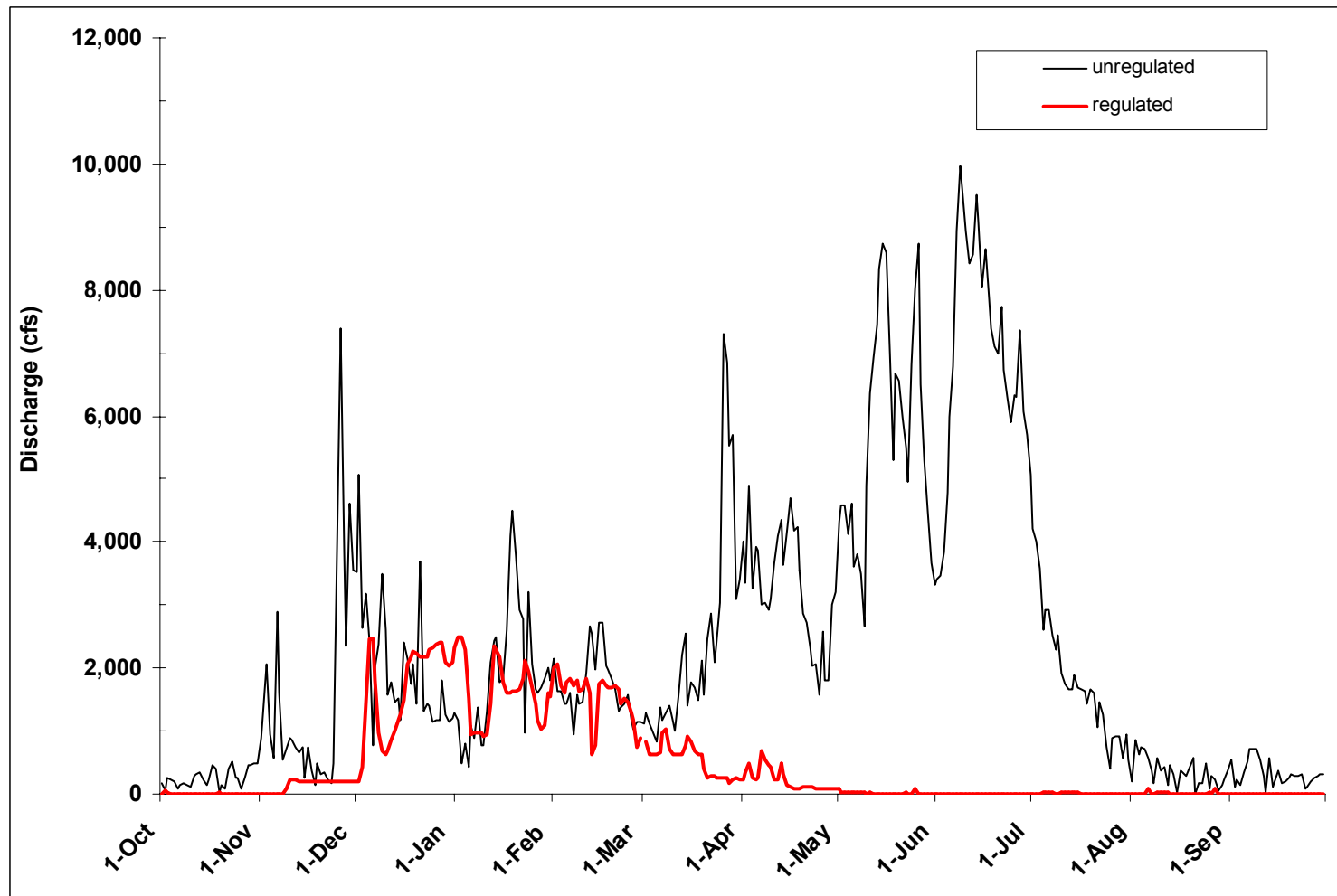


Figure 14: Tuolumne River annual hydrographs of inflow to New Don Pedro Reservoir (unregulated) and flow at La Grange (regulated) for a normal water year (1971). Source: McBain and Trush 2000.

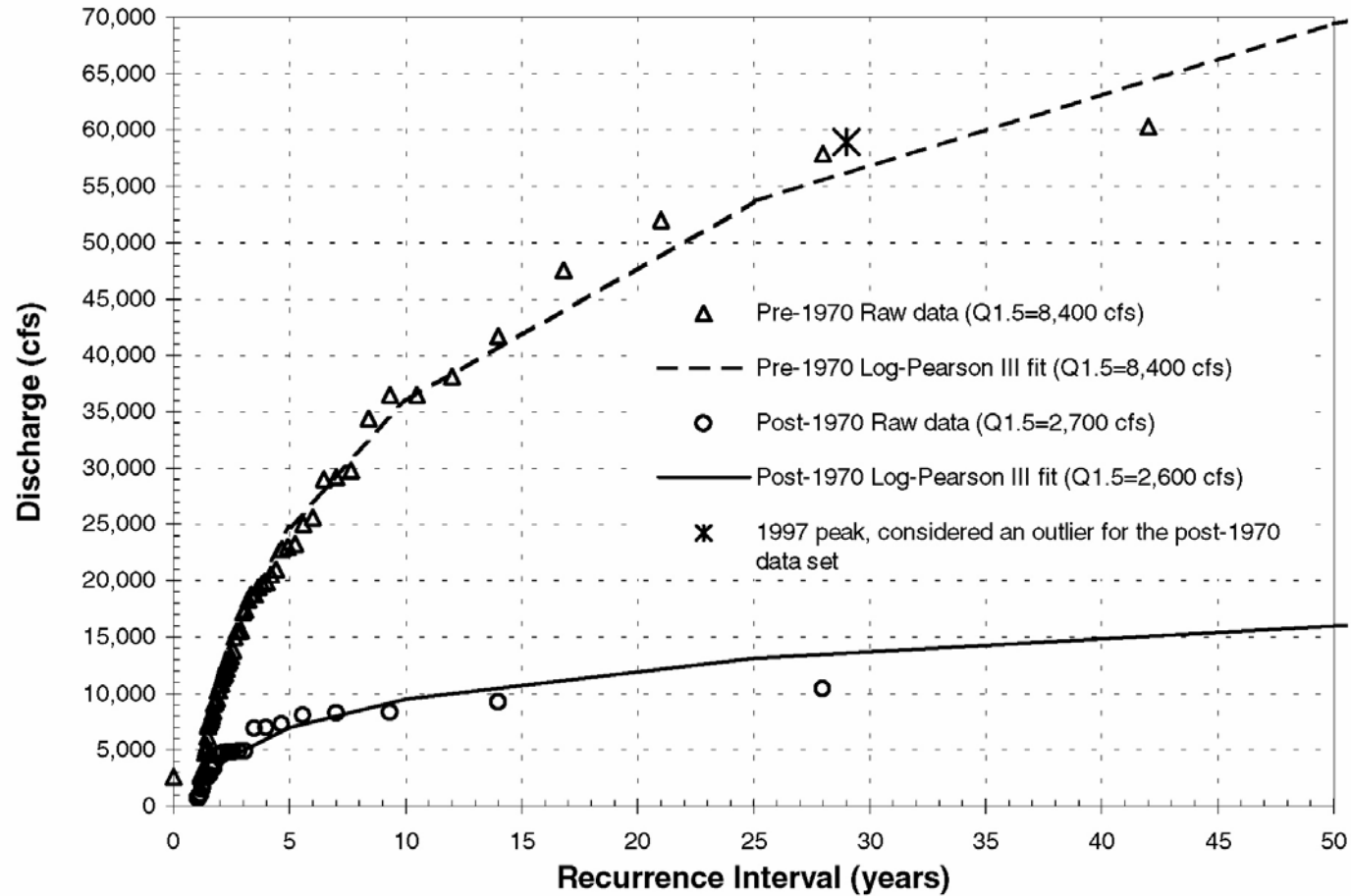


Figure 15: Tuolumne River annual maximum flood frequency curves for unimpaired and post-New Don Pedro Project periods at La Grange. Source: McBain and Trush 2000.

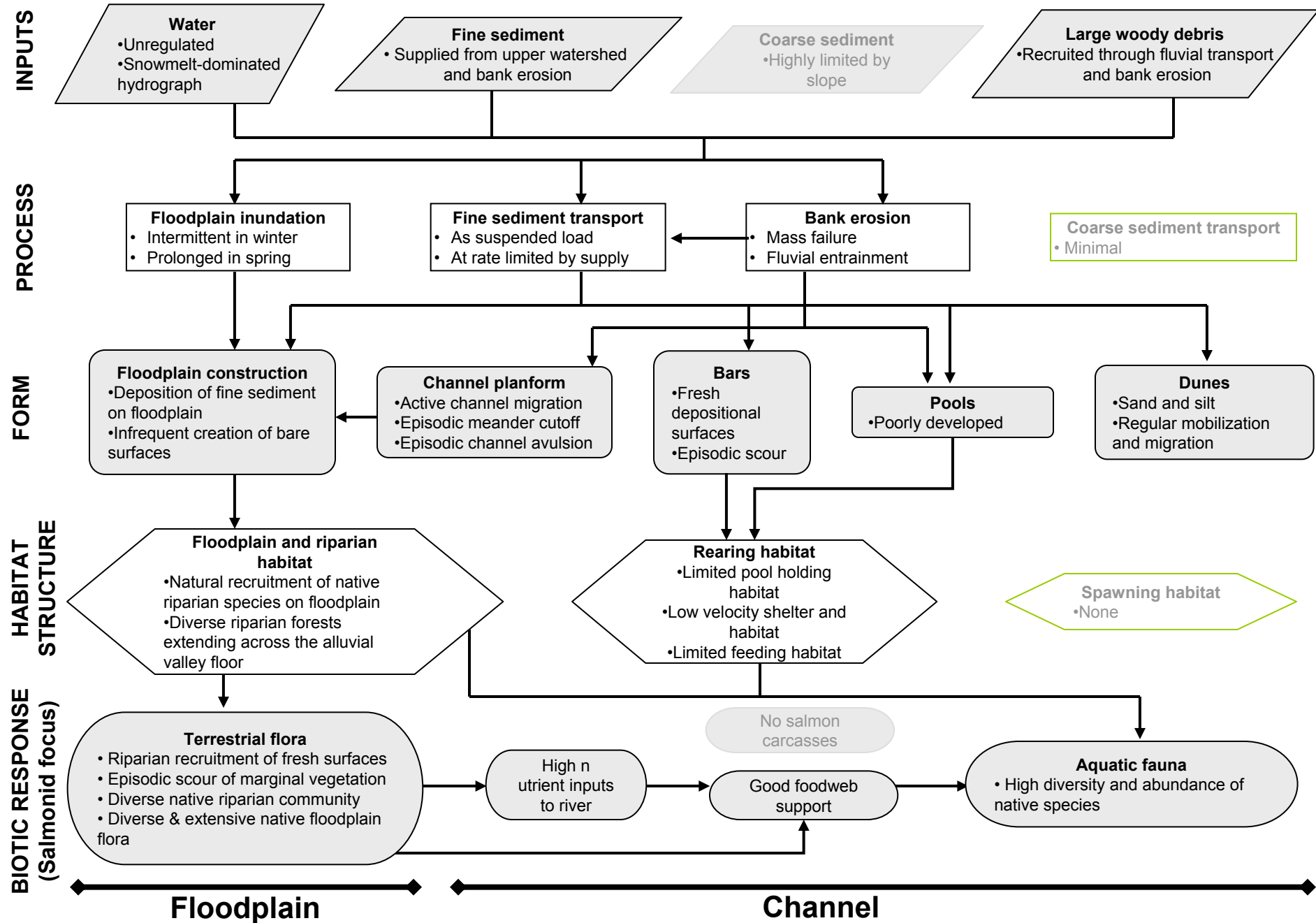


Figure 16: Sand bed (unconfined) reference condition conceptual model.

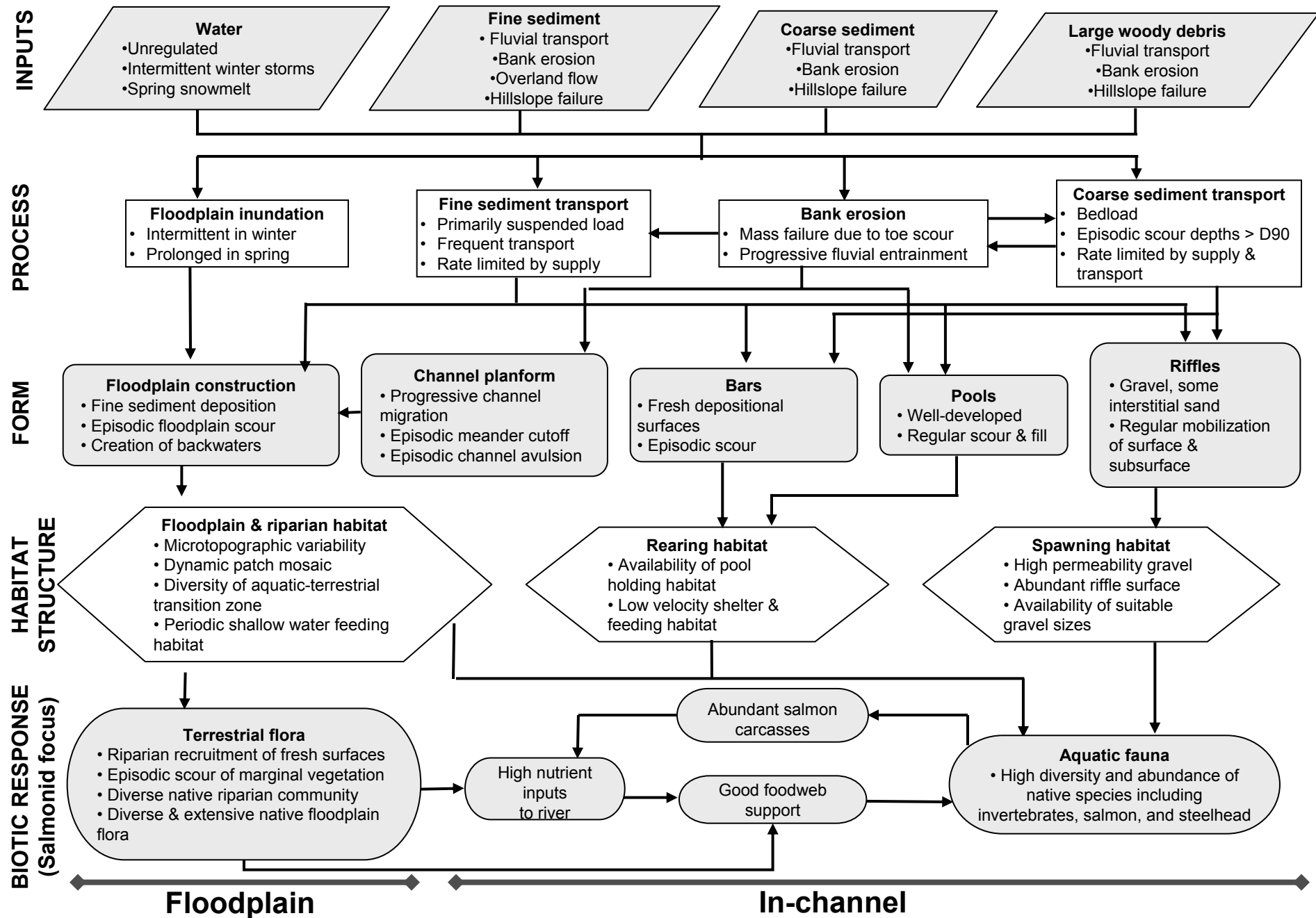


Figure 17: Gravel bed (unconfined) reference condition conceptual model.

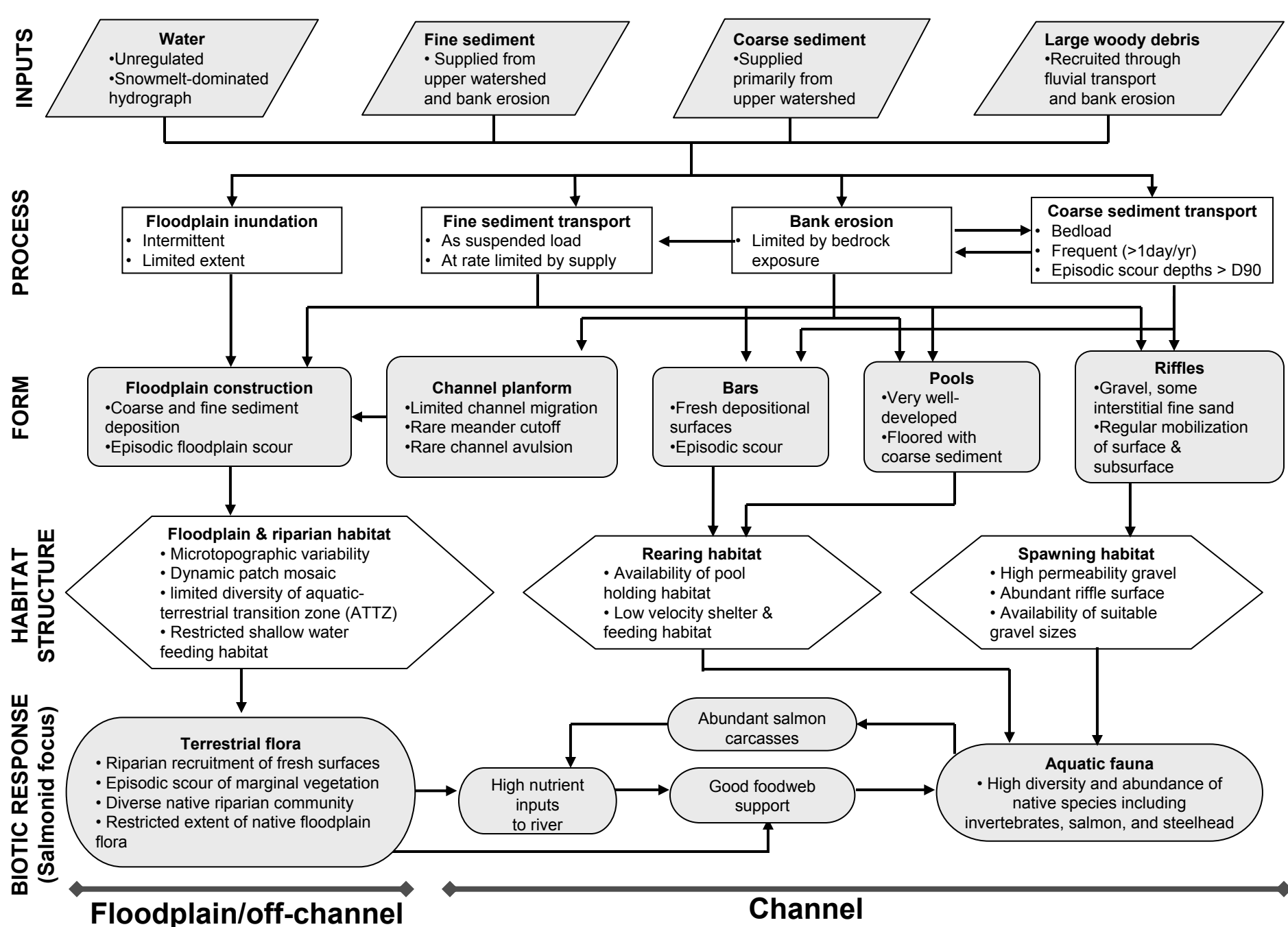


Figure 18: Gravel bed (confined by bedrock banks, limited floodplain) reference condition conceptual model.

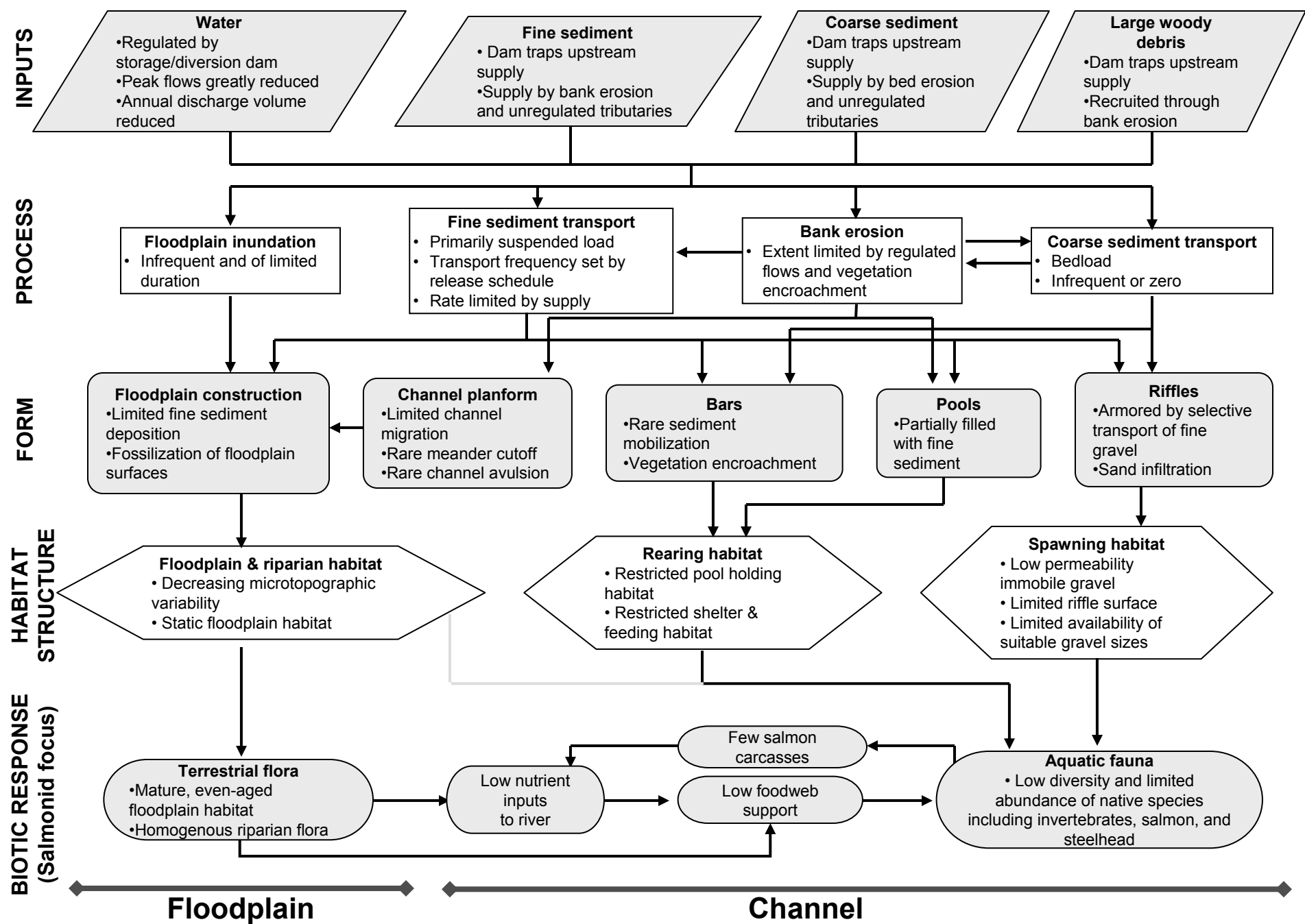


Figure 19: Gravel bed (unconfined) disturbed by dam conceptual model.

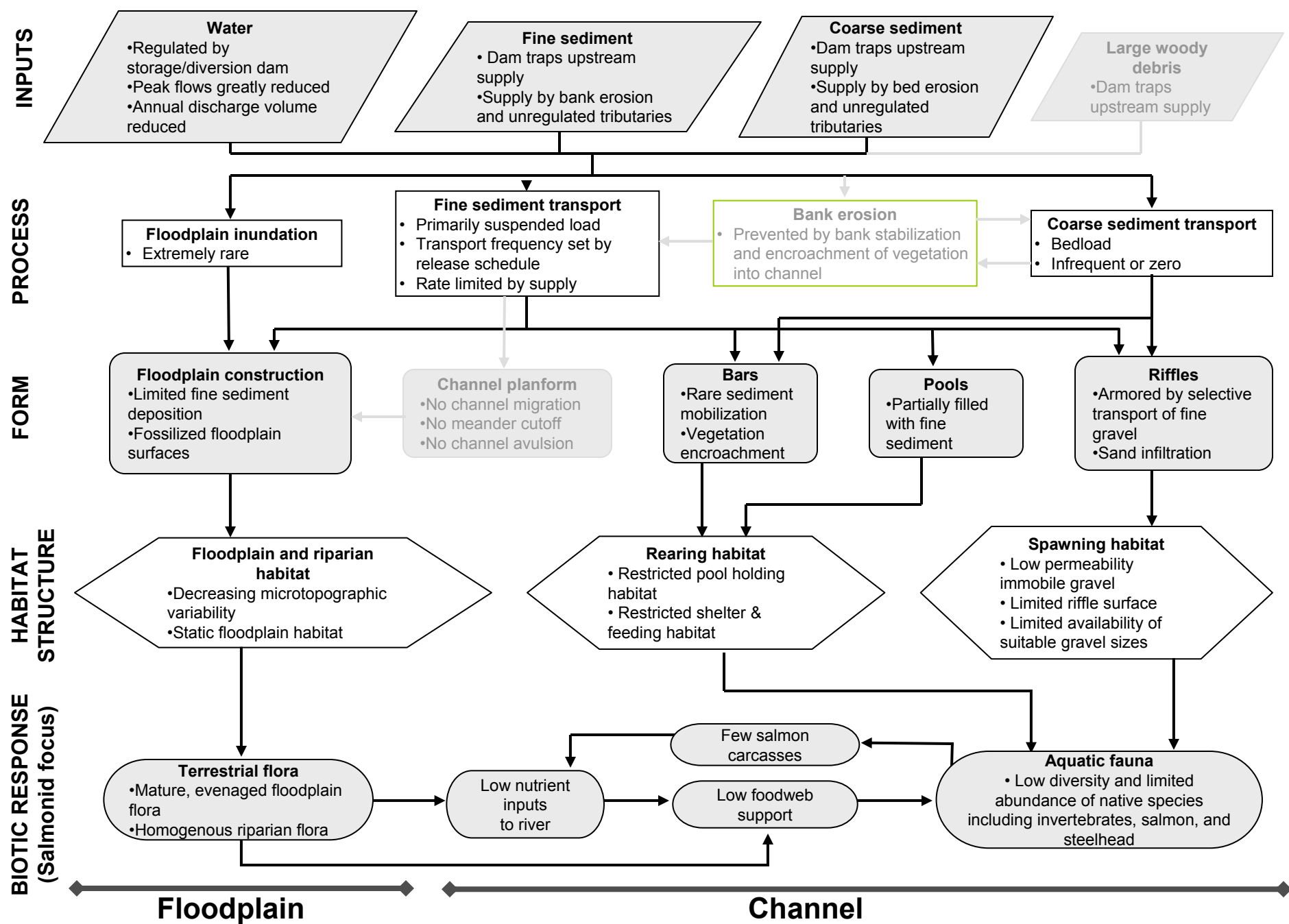


Figure 20: Gravel bed (unconfined) disturbed by dam and by protected levees conceptual model.